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Claims searched:	ALL	**Date of search:**	18 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4R:RSAD, RSS, RST, RSX

Int Cl (Ed.6): H04R, H04S

Other: Online: WPI, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2276298 A	CENTRAL - see especially figures 1, 4, 5	1
A	EP 0357402 A2	Q SOUND - see especially figures 8, 12	1
A	WO 94/24836 A1	SIXGRAPH - see especially figure 1	1
A	US 5371799	LOWE -see especially figures 3,7, 10, 11	1

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

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H04B 1/12

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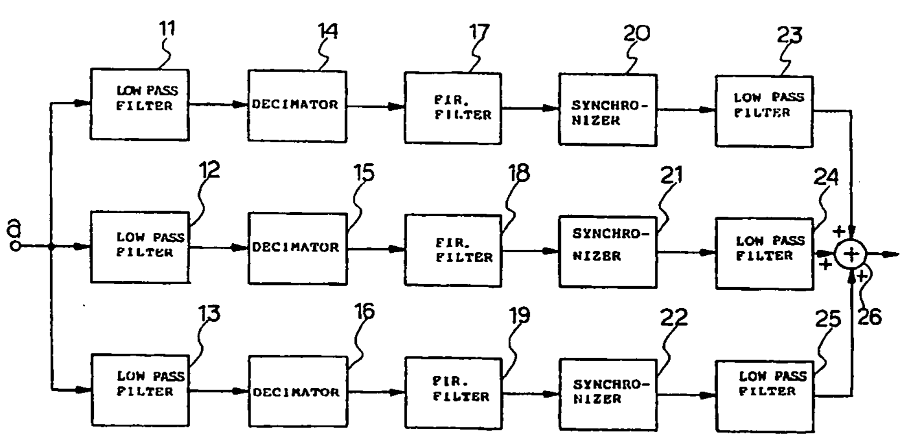
(54) Correcting sound signal distortion

(57) Apparatus for correcting sound signal distortion by way of audio frequency band segmentation comprises: frequency band segmentation means 11, 12, 13 for segmenting an audio frequency band sampled by a predetermined frequency into a plurality of bands; decimation means 14, 15, 16 for performing decimation in respectively different ratios for each sound data band segmented by the frequency band segmentation means 11, 12, 13; distortion correcting means 17, 18, 19 for performing distortion correction in each band on the sound data decimated from the decimation means 14, 15, 16; and data output means 20-25 for synchronizing the sound data distortion-corrected by the distortion correcting means 17, 18, 19 so that the sound data can be in the same order as the sound data when input to the frequency band segmentation means 11, 12, 13 thereby to be output in synthesis. The audio frequency band is segmented into a plurality of frequency bands by way of a Bark Scale which represents man's sound distinguishing calibre in the audio frequency band, and in the low frequency band the sampling rate of the sound data is increased whereas in the high frequency band, the sampling rate is decreased, thereby to constitute effective digital signal processing filters with fewer circuit elements.

FIG. 2



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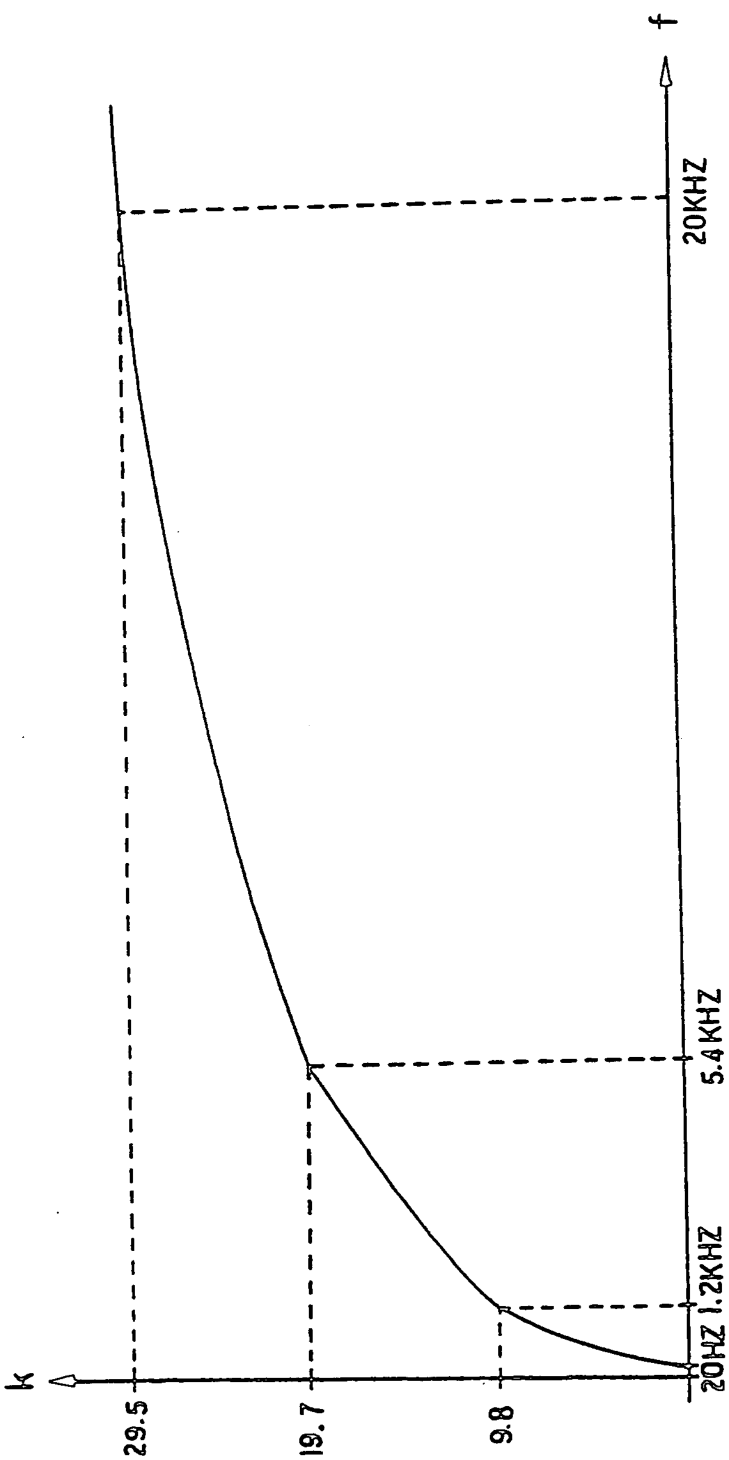
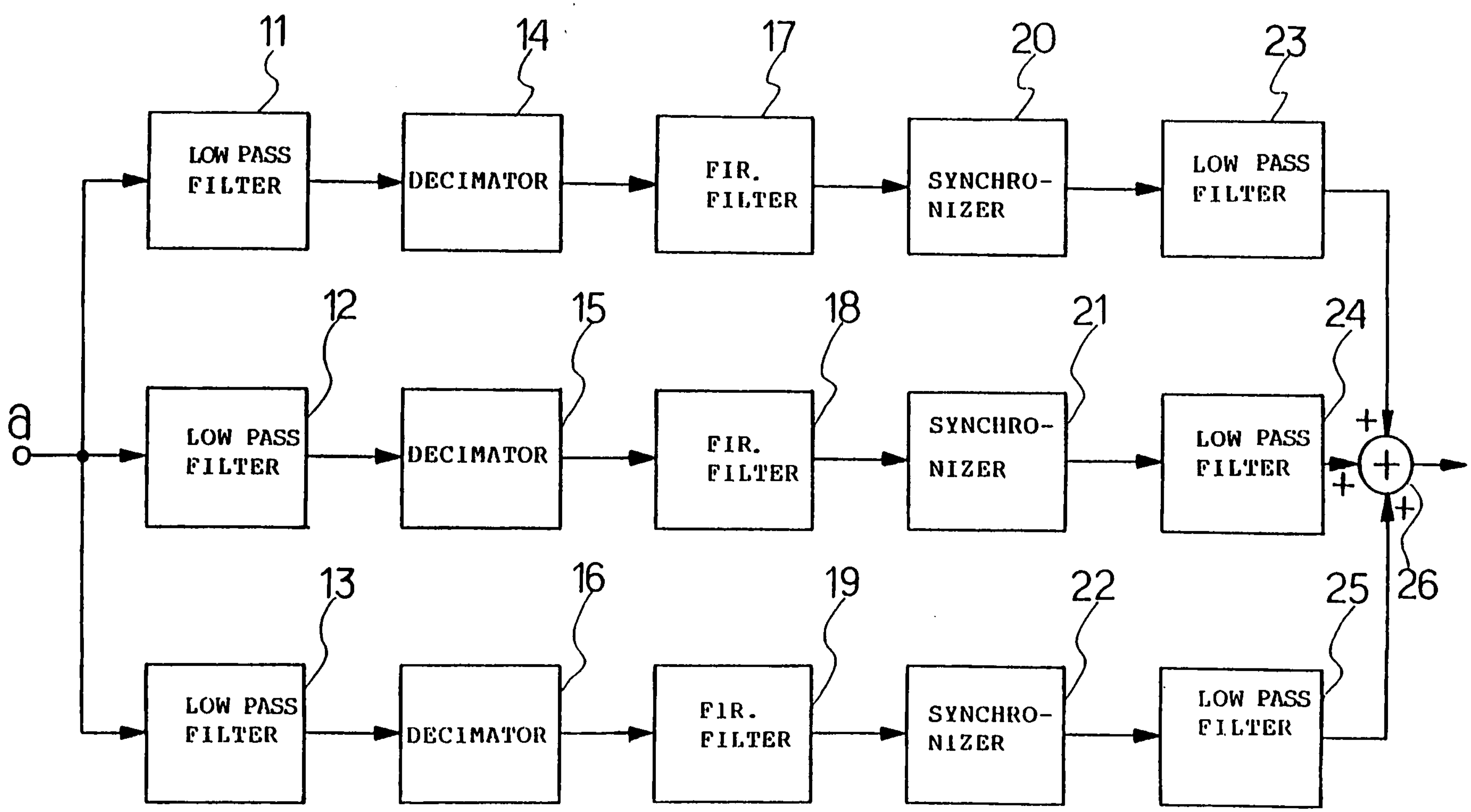


FIG. 1

FIG. 2



a
LOW PASS FILTER
DECIMATOR
FIR. FILTER
SYNCHRO-NIZER
LOW PASS FILTER
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CORRECTING SOUND SIGNAL DISTORTION

The present invention relates to apparatus for correcting sound signal distortion.

Most sound instruments change an electrical signal to a mechanical signal, so that a sound signal is generated by the mechanical signal which creates vibration. In this process, an original sound signal usually has its signal distorted by a transfer function possessed by the system.

Accordingly, before the electrical signal is converted to the mechanical signal, the distortion created by the aforesaid transfer function can be corrected by applying an electrical signal corresponding to an inverse function of the transfer function via a Digital Signal Processing (DSP) filter. In order to correct the distortion by way of the DSP filter, a sampling should be made on a frequency band reproduced by a speaker.

However, the sampling of an entire audio frequency band has been conventionally done on at certain intervals. An accurate distortion correction could be possible for almost all the frequencies if the sampling frequency were increased, but this gives rise to the problem that the number of circuit elements comprising the DSP filter then increases greatly.

If the sampling frequency is decreased, the number of circuit elements comprising the filter decreases, but there then arises a problem in that the accuracy of the distortion correction deteriorates.

For example, in Japanese laid open Patent Application No. Sho 63(1988)-50195 entitled, "Audio Signal Transmission System", a technique has been proposed in such a manner that a signal is segmented in accordance with a result of a spectrum analysis for an input audio signal when the input signal is performed by a signal segmentation according to respective frequency bands in order to cope with a plurality of output means.

In other words, in order to faithfully reproduce the entire bands of the audio signal (in order to minimize the distortion), a technique has been provided to segment the frequency bands in accordance with the spectrum of the analysed audio signal.

According to this Japanese laid open Patent Application No. Sho 63-50195, the audio signal transmission system can prevent generation of cross-over distortion for a desired characteristic, but there has been no way whatsoever to solve the aforementioned problems.

Accordingly, it is an aim of preferred embodiments of the present invention to provide an apparatus for correcting sound signal distortion by way of an audio frequency band segmentation, utilizing a Bark Scale for representing man's sound distinguishing calibre in the audio frequency bands, dividing the audio frequency bands into a plurality of frequency bands, decreasing the number of samplings in high frequency bands, and increasing the number of samplings of the sound signal in low frequency bands to thereby comprise an effective DSP filter by way of a fewer circuit elements.

According to one aspect of the present invention, there is provided an apparatus for correcting sound signal distortion by way of audio frequency band segmentation, the apparatus comprising:

frequency band segmentation means for segmenting an audio frequency band sampled at a predetermined frequency into a plurality of bands;

decimation means for performing declination in accordance with a respective ratio on each of the sound data bands segmented by the frequency band segmentation means;

distortion correcting means for performing in each band distortion correction on the sound data decimated by the respective decimation means; and

data output means for synchronizing the sound data distortion-corrected by the distortion correcting means, so that the sound data from the segmented bands are in the same order as the sound data when input to the frequency band segmentation means, and then combining and outputting the synchronised data.

Preferably, the frequency band segmentation means segments the audio frequency band according to a Bark Scale.

Preferably, the frequency band segmentation means comprises a plurality of low pass filters for segmenting the audio frequency band.

Preferably, the low pass filters comprise more than two filters.

Preferably, the decimation means comprises a plurality of decimators for performing decimations with mutually different decimation ratios.

Preferably, the decimation means comprises more than two decimators.

Preferably, the distortion correcting means comprises finite impulse response filters for distortion-correcting the sound data in each band.

Preferably, the data output means comprises a plurality of synchronizers for synchronizing the sound data in the same order as the sound data when input to the frequency band segmentation means.

Preferably, the data output means comprises low pass filters for removing noise from data synchronized by the synchronizers in each band; and an adder for combining the data from the bands, with noise removed by the low pass filters.

Preferably, the low pass filters of the data output means correspond to the frequency pass bands of the low pass filters of the frequency band segmentation means.

According to another aspect of the present invention, there is provided an apparatus for correcting noise distortion in an audio signal, the apparatus comprising means for segmenting an input audio signal into discreet frequency bands, means for weighting the segmented audio signals in ratios derived from a Bark Scale, means for carrying out noise correction in each band, and means for subsequently combining the noise-corrected signals from each segmented band to form an output signal.

Such an apparatus may further comprise any one or more of the features disclosed in the accompanying specification, claims, abstract and/or drawings, in any combination.

The invention extends to an audio signal playing or processing means provided with an apparatus according to any of the preceding aspects of the invention.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a graphical plot of a Bark Scale; and

Figure 2 is an example of one embodiment of an apparatus for correcting sound signal distortion by way of an audio frequency band segmentation in accordance with the present invention.

A Bark Scale is provided for showing a capacity (audiogenic resolution) for distinguishing sound signals of different frequencies in the audio frequency band. In the Bark Scale, man's audiogenic resolution is represented in a frequency domain. As shown in Figure 1, an audio frequency band of 20HZ-20KHZ is represented as an exponent for distinguishing the Bark Scale. Man's audiogenic resolution (k) is displayed as a curved incline in the Bark Scale illustrated in Figure 1. Man's audiogenic resolution in a low frequency domain is higher than that in a high frequency domain.

In other words, man is more apt to detect easily a frequency variation of a sound signal with a steeper curve slope in the low frequency domain and is more apt to detect with difficulty a frequency variation of a sound signal with a gentler curve slope in the high frequency domain.

In Figure 2, the frequency band segmentation means for segmenting the audio frequency band sampled by a predetermined frequency into a plurality of bands comprises a first low filter 11, a second low pass filter 12 and a third low pass filter 13.

The first, second and third low pass filters 11, 12 and 13 have respective different frequency pass bands. In other words, the filters have frequency pass bands in accordance with the Bark Scale.

A decimation means for performing a decimation in different respectively ratios in accordance with the sound data bands band-segmented by the frequency band segmentation means comprises three decimators 14, 15 and 16.

A distortion correcting means for distortion-correcting per band the sound data decimated from the decimation means comprises Finite Impulse Response FIR filters 17, 18 and 19 for performing a finite impulse response.

A data output means wherein the sound data distortion-corrected by the distortion correcting means is synchronized in order to be in the same order as the sound data when input into the frequency band segmentation means thereby to be output in synthesis comprises synchronizers 20, 21 and 22, fourth, fifth and sixth low pass filters 23, 24 and 25 and an adder 26.

The synchronizers 20, 21 and 22 in the data output means restructure time-wise the data output from the FIR filters 17, 18 and 19 in order that the output can be in the same order with the sound data when input.

The fourth, fifth and sixth filters 23, 24 and 25 eliminate noises of the data output from the synchronizers 20, 21 and 22.

Here, each of the first, second and third low pass filters 11, 12 and 13 is constructed to have the same frequency pass band as the fourth, fifth and sixth low filters 23, 24 and 25 on the same line.

The adder 26 adds the data output from the synchronizers 20, 21 and 22 thereafter to output the same.

Accordingly, when the sound data of the audio frequency band sampled at a predetermined sampling frequency (generally 44.1KHz) is input to the apparatus of Figure 2 through an input terminal a, the first, second and third low pass filters 11, 12 and 13 divide the sound data into three frequency bands according to the exponent k in the Bark Scale as illustrated in Figure 1.

In other words, the first low pass filter 11 passes sound data of the first frequency band (2OHz-1.2KHz) which has an exponent k of 0-9.8, the second and third low pass filters 12 and 13 pass sound data of the second and third frequency bands (1.2KHz-5.4KHz, 5.4KHz-20KHz) which have exponents k of 9.8KHz-19.7KHz and 19.7KHz-29.5KHz respectively, so that the input sound data can be divided into three frequency bands.

When the sound data divided into three frequency bands by the first. second and third low pass filters are respectively input into the first, second and third decimators 14, 15, 16, the respective decimators decimate the input sound data in a respective prescribed ratio.

The first decimator 14 selects one data out of 15 sampling data thereafter to output the same, and therefore performs a 15-to-1 declination method of disregarding the balance of 14 data.

The second decimator 15, in the same method as in the first decimator 14, selects one data out of 3 sampling data thereby to output the same and perform a 3-to-1 decimation method of disregarding the balance of 2 data.

The third decimator 16 performs a 1-to-1 decimation thereby to output the input data as it is.

Here, the 3-to-1 decimation rate equates to a sampling frequency of 14.7 KHz which is one third of the sampling frequency possessed by the sound data when passing through the input terminal a, which is actually the same as the sampled sound data.

In other words, one data out of 3 data sampled in a sampling frequency of 44.KHz is selected thereby to output the same, which becomes the same as the sound data input at 14.7 KHz (=44.1 KHz/ 3). Accordingly, the output data of the first decimator 14 which is 2.94KHz (=44.1KHz/15) actually becomes the same as the result of the sampled sound data.

The FIR filters 17, 18 and 19 correct amplitude distortions and phase distortions of the distorted data output from the decimators 14, 15 and 16.

At this moment, if the FIR filters are equipped with a total of 200 taps, the first, second and third frequency bands will respectively have 34, 68 and 98 taps.

Accordingly, the resolution for each band can be obtained from sampling frequency/(tap number x decimation rate), which reads as below:

TABLE 1

	Bark Scale	Frequency range	tap number	resolution
1st band	0 - 9.8	20 Hz - 1.2 KHz	34	approx. 90Hz
2nd band	9.8 - 18.7	1.2 KHz - 5.4 KHz	68	approx. 200Hz
3rd band	19.7 - 29.5	5.4 KHz - 20 KHz	98	approx. 450Hz

In other words, the respective resolutions at the first, second and third bands read as "44.1KHz/(34x15)≒9OHz", "44.1KHz/(68x3)≒200Hz" and "44.1KHz/(98x1)≒45OHz".

In the above table, the frequency ranges and Bark Scales corresponding to each band are identical to the ones in Figure 1, and the number of taps is determined in consideration of man's audiogenic resolution in each frequency band and integrated circuits comprising the taps and the like.

Therefore, the first FIR filter 17 has 34 taps, and the second and third FIR filters 18 and 19 are constructed to have 68 and 98 taps respectively.

In the above Table 1, the resolution of 9OHz implies that a frequency difference between one predetermined sound data and another predetermined sound data is 9OHz.

When the distortion-corrected sound data are output from the respective FIR filters having mutually different taps, the synchronizers 20, 21 and 22 connected to the outputs of the FIR filters synchronize the sound data input in accordance with a predetermined controller command(not shown).

In other words, the sound data decimated and filtered by band segmentation are connected time-wise in order that the same can be in the same order as the sound data passing through the input terminal a.

The data output from the first synchronizer 20 is re-filtered by the fourth low pass filter 23 thereby to remove noise, and noise in the data output from the second and third synchronizers 21 and 22 is removed by the fifth and sixth low pass filters 24 and 25 respectively.

The sound data with noise removed by the above-mentioned fourth, fifth and sixth low pass filters 23, 24 and 25 have the same frequency bands respectively as the frequency pass bands of the first, second and third low pass filters 11, 12 and 13 situated on the same line.

The adder 26 adds the sound data with noise removed by the fourth, fifth and sixth low pass filters 23, 24 and 25 so that the same can be output.

According to the above-described apparatus for correcting sound signal distortion by way of audio frequency band segmentation, there is an effect of constructing the DSP filters effectively with a fewer number of circuit elements by utilizing man's audiogenic resolutions.

The foregoing description and drawings are illustrative and are not to be taken as limiting. Still other variations and modifications are possible without departing from the scope of the present invention.

Specifically, in the foregoing embodiment, the audio frequency band has been segmented into three bands, but according to requirements, the bands can be increased or decreased.

The illustrated embodiment of the invention therefore provides apparatus for correcting sound signal distortion by way of an audio frequency band segmentation for correcting the sound signal distortion utilizing a Bark Scale that represents a human sound distinguishing capacity in such systems as sound recognizing instruments, sound reproducing instruments, transducers, acoustic sensors and the like calling for linear characteristics.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any

method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS:

1. An apparatus for correcting sound signal distortion by way of audio frequency band segmentation, the apparatus comprising:

frequency band segmentation means for segmenting an audio frequency band sampled at a predetermined frequency into a plurality of bands;

decimation means for performing declination in accordance with a respective ratio on each of the sound data bands segmented by the frequency band segmentation means;

distortion correcting means for performing in each band distortion correction on the sound data decimated by the respective decimation means; and

data output means for synchronizing the sound data distortion-corrected by the distortion correcting means, so that the sound data from the segmented bands are in the same order as the sound data when input to the frequency band segmentation means, and then combining and outputting the synchronised data.

2. An apparatus according to claim 1, wherein the frequency band segmentation means segments the audio frequency band according to a Bark Scale.

3. An apparatus according to claim 1 or 2, wherein the frequency band segmentation means comprises a plurality of low pass filters for segmenting the audio frequency band.

4. An apparatus according to claim 3, wherein the low pass filters comprise more than two filters.

5. An apparatus according to any of the preceding claims, wherein the decimation means comprises a plurality of decimators for performing decimations with mutually different decimation ratios.

6. An apparatus according to any of the preceding claims, wherein the decimation means comprises more than two decimators.

7. An apparatus according to any of the preceding claims, wherein the distortion correcting means comprises finite impulse response filters for distortion-correcting the sound data in each band.

8. An apparatus according to any of the preceding claims, wherein the data output means comprises a plurality of synchronizers for synchronizing the sound data in the same order as the sound data when input to the frequency band segmentation means.

9. An apparatus according to claim 8, wherein the data output means comprises low pass filters for removing noise from data synchronized by the synchronizers in each band; and an adder for combining the data from the bands, with noise removed by the low pass filters.

10. An apparatus according to claims 3 and 9, wherein the low pass filters of the data output means correspond to the frequency pass bands of the low pass filters of the frequency band segmentation means.

11. An apparatus for correcting noise distortion in an audio signal, the apparatus comprising means for segmenting an input audio signal into discreet frequency bands, means for weighting the segmented audio signals in ratios derived from a Bark Scale, means for carrying out noise correction in each band, and means for subsequently combining the noise-corrected signals from each segmented band to form an output signal.

12. An apparatus according to claim 11, further comprising any one or more of the features disclosed in the accompanying specification, claims, abstract and/or drawings, in any combination.

13. An apparatus for correcting noise distortion in an audio signal, the apparatus being substantially as hereinbefore described with reference to the accompanying drawings.

14. An audio signal playing or processing means provided with an apparatus according to any of the preceding claims.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9317308.6

Relevant Technical Fields

(i) UK Cl (Ed.L) H4R: RPNR; RPX

(ii) Int Cl (Ed.5) G10L, H04B

Search Examiner
AL STRAYTON

Date of completion of Search
20 OCTOBER 1993

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE: WPI

Documents considered relevant following a search in respect of Claims :-
ALL

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2252023 A	
A	EP 0400755 A1	
A	US 4956871	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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